

**The New England Seismic Network**  
Operated Collaboratively by M.I.T. and Boston College  
Annual Project Summary  
October 1, 1999 - September 30, 2000

External Grant Award Number 1434-HQ-98-AG-01926

**M. Nafi Toksöz**  
Massachusetts Institute of Technology  
Earth Resources Lab  
42 Carleton Street  
Cambridge, MA 02142

Telephone: (617) 253-7852  
FAX: (617) 253-6385  
toksoz@mit.edu  
[www-erl.mit.edu/NESN/homepage.html](http://www-erl.mit.edu/NESN/homepage.html)

**NEHRP Element(s): II**  
**Keywords:** Wave Propagation, Source Characteristics, Seismotectonics

## **Investigations Undertaken**

The Earth Resources Lab (ERL) of MIT and the Weston Observatory (WES) of Boston College operate jointly the New England Seismic Network (NESN). The function of the NESN is to continuously record seismic ground motions for the following purposes: 1) to determine the location and magnitude of earthquakes in and adjacent to New England and to report this information to public safety agencies, 2) to conduct research with the recorded data on the seismic hazard in New England, and 3) to educate the public about earthquake hazard in New England.

The NESN continuously monitors earthquake activity in and adjacent to New England. A primary objective of this operation is to detect and report the location and size of regional earthquakes in a timely manner to the public and agencies responsible for their safety. A major task designed to enhance this objective involves implementation of Earthworm at the regional seismic networks to facilitate the automated exchange and processing of waveform and parametric data among network operators. The Earth Resources Lab has begun using and developing its Earthworm capabilities in conjunction with upgrading the hardware of its seismic stations. This is an ongoing task, which will speed up the dissemination of and improve the quality of current earthquake information, while at the same time expanding coverage of seismicity for the northeastern US as a whole.

Various types of research investigations form the basis for improving our knowledge of the seismic hazard in New England. They include studies on seismotectonics, crustal and upper mantle structure, earthquake source parameters, attenuation of the recorded ground motions, and statistics (e.g., probability of occurrence) of the seismicity. All of these studies provide results useful to improving our estimation of the seismic hazard in New England.

Data management and dissemination are essential operations which support all network activities. Current improvements are aimed at accelerating the delivery of data on current earthquakes, expanding

the quantity of general earthquake information available to the public (primarily on the web), and facilitating the dissemination of parametric and waveform data to researchers.

This report includes a non-technical summary which provides a brief overview of the objectives of this project.

## **Results**

### **Seismic Network Monitoring**

From October 1, 1999 - September 30, 2000, the Earth Resources Lab at MIT operated four digitally recording short-period stations located in southern New Hampshire and eastern Massachusetts and a newer three-component, broadband instrument at Station WFM (Figure 1). Data from the short-period stations are streamed continuously in analog mode to a central digitizer at ERL. An STA/LTA algorithm running on a PC processes the digitized ground motion to search for seismic events. Event triggers are manually scanned to discriminate different types of seismic events (i.e., teleseisms, explosions, local and regional earthquakes). The broadband station digitizes (24-bit) ground motions on-site and the data is streamed continuously to the PC-based central processing station at ERL. The broadband sensor is a Guralp CMG-40T with a frequency response flat to velocity from .03 seconds to 50 Hz. Three existing stations (DXB, GLO, and DNH, see Figure 1) are scheduled for upgrading in the Fall of 2000, with the same equipment. In addition, one new station with a fifth three-component, broadband instrument is being planned for a suitable site near Provincetown, MA to improve both the overall coverage of New England and the azimuthal coverage of the Boston area (Figure 1). The equipment for these four upgrades has been received at ERL. Upon the request of the USGS, the sensor model for the latest procurement of two seismometers was changed from the CMG-40T to the CMG-3ESP to further enhance data quality. The WES of Boston College intends to install three additional broadband stations, two in Maine and one in northern New Hampshire (Figure 1). The total number of NESN stations operating in New England is currently sixteen, with thirteen broadband and four short-period instruments.

Following the cooperative monitoring plan developed by ERL and WES, ERL operates its stations at local distances (<100 km) around Boston, while WES distributes stations broadly throughout New England. This plan insures that the region with the highest seismic risk (eastern Massachusetts) is provided with the densest station coverage to measure earthquake ground motions, while still monitoring the widely scattered source zones of potentially strong earthquakes throughout New England. Defining ground-motion hazard in urban areas is a major objective of the regional seismic networks in cooperation with the USGS, and WES and ERL are configuring the NESN to address that objective, while still maintaining broad coverage of the seismicity scattered throughout New England.

Continuous telemetry, from the field site to ERL, is being preserved for all upgraded stations of the MIT portion of the NESN. This mode of transmission provides continuous, real-time data at ERL for rapid knowledge of the occurrence of an earthquake. A continuous data stream is also necessary to use Earthworm as the means to process waveform data (e.g., export/import data to/from other networks, develop automated phase picking and earthquake location capabilities).

In May of 2000, the operator of the MIT NESN received training at the NEIC in Golden, Colorado in the use of Earthworm. Subsequently, Earthworm was installed on a Pentium III PC running Windows NT at ERL as the new MIT network interface with the US National Seismic Network of the USGS and

the Lamont-Doherty Cooperative Seismographic Network operated by Lamont-Doherty Earth Observatory (LDEO). Currently, the MIT NESN exports waveform data from broadband Station WFM, and imports USNSN stations in the northeastern US (i.e., LBNH, LSCT, NCB, BINY, SSPA, and GWDE) and Lamont-Doherty Station PAL (Figure 1). In addition, the MIT NESN imports WES Stations WES and HNH (in trigger mode) via the NEIC data communications hub in Golden. At present, event waveforms are extracted manually from the continuous data streams and converted to SAC format for processing to locate an earthquake (Figure 2). Future plans call for tuning Earthworm's triggering and phase picking modules to automatically process the waveform data and obtain a hypocenter and magnitude for an event.

The epicenters of all local and regional earthquakes recorded and located by the NESN for the period October 1, 1999 - September 30, 2000 are displayed in Figure 3. Fifteen earthquakes, with magnitudes of 0.9 - 3.8, occurred during this period. Among these events, there appear to be two pairs of related earthquakes based on similar hypocenters. One pair occurred in southeastern New Hampshire only six days apart, the first event with a magnitude of 2.4 and the second with a magnitude of 3.0. The second pair occurred near Springfield, MA, the first an M3.0 earthquake followed about two months later by an M1.9 event.

### **Data Management and Dissemination**

The waveforms of regional and local earthquakes are analyzed to provide hypocentral and arrival time information for earthquakes in and adjacent to New England. The arrival times and coda durations are measured from the seismograms recorded by the MIT seismic stations and combined with arrival time and magnitude data for the WES stations to determine the hypocenter solution for local and regional earthquakes. Data from stations operated by the Geological Survey of Canada and the Lamont-Doherty Cooperative Seismographic Network are also incorporated into the earthquake locations when appropriate. The hypocentral parameters and associated earthquake maps are compiled and made available to the public on our web-site, "[www-erl.mit.edu/NESN/homepage.html](http://www-erl.mit.edu/NESN/homepage.html)". The homepage features a "Newsflash", which is an epicentral map of a current felt earthquake in, or adjacent to, New England. The "Newsflash" is posted as soon as possible after the earthquake, which is usually within a couple hours of its occurrence. Hypocenter information is also posted on the WES web-site, "[www.bc.edu:80/bc\\_org/avp/cas/wesobs/](http://www.bc.edu:80/bc_org/avp/cas/wesobs/)".

During the period of this report, ERL and WES published a joint quarterly seismic bulletin, which contains the hypocenter solutions for regional earthquakes in and adjacent to New England, and is based on the combined station nets operated by the two institutions. This bulletin is not intended to replace the Northeastern United States Seismic Network (NEUSSN) Bulletin. Instead, it is a preliminary report that is designed to be more complete and widely accessible than past quarterly progress reports published by the individual institutions. The NEUSSN Bulletin remains as the final report on earthquake activity in and around the northeastern United States. This report is also posted on the WES web-site, with a link to it from the ERL web-site.

ERL has continued to develop its in-house map-making capabilities and spatial database with ARCINFO (*e.g.*, earthquake and seismic station coverages, shaded-relief and elevation grids, theme maps of natural, cultural, geopolitical features). This work has multiple purposes, including the creation of the NESN earthquake bulletin, the rapid posting of epicentral maps for current earthquakes ("Newsflash"), maps for reports, and spatial analysis capabilities for regional earthquake research.

WES is working on distributing hypocenter data about NESN earthquakes to the CNSS Composite Catalog. For now ERL will continue to provide its station arrival times and magnitude parameters via FTP and e-mail to WES for incorporation into the event hypocenter solutions to be eventually shipped to the CNSS Catalog.

### *Data Availability*

We continue to provide two internet utilities, the MIT/ERL web-site ("[www-erl.mit.edu/NESN/homepage.html](http://www-erl.mit.edu/NESN/homepage.html)") and an anonymous FTP directory, to distribute seismic data. SESAME (Seismic Event Server at MIT/ERL) is the web data server that distributes catalogs, reports, earthquake bulletins, and epicenter and station maps (including an archive of recent seismic events). The FTP site, named "[sunda.mit.edu](http://sunda.mit.edu)", is the current facility available to download waveform data recorded by the MIT NESN. The client machine IP number must be forwarded to us for the client to gain access to the anonymous FTP directory. After logging on, the user changes directories to "pub/seismic". Waveforms of individual events for the period April 1995 through the present are accessed as Unix-compressed SAC files, through the anonymous FTP directory. A "readme" file offers further explanation about the data. Older waveform data in SAC format (1981 - March 1995) will be made available on the FTP site upon request.

Detailed information about events (arrival times, crustal model, azimuthal coverage plots, etc.) is published in the quarterly seismic bulletins. These are currently available for the MIT portion of the NESN in hard copy for the period October 1979 - December 1997, and as HTML documents on our web-site for 1996 and 1997. The unified bulletins (WES and ERL stations) are accessible as HTML documents on our web-site for January 1998 - June 1999. Hypocenter data and epicenter maps for individual earthquakes are published up to the present on our web-site and the WES web-site ("[www.bc.edu:80/bc\\_org/avp/cas/wesobs/](http://www.bc.edu:80/bc_org/avp/cas/wesobs/)"). For more information about MIT NESN data contact Charles Doll at [doll@erl.mit.edu](mailto:doll@erl.mit.edu) or 617-253-7863.

### **Reports Published**

A Study of New England Seismicity, *Quarterly Earthquake Reports, New England Seismic Network*, April-June 1998, July-September 1998, October-December 1998, January-March 1999.

# NESN Station Map

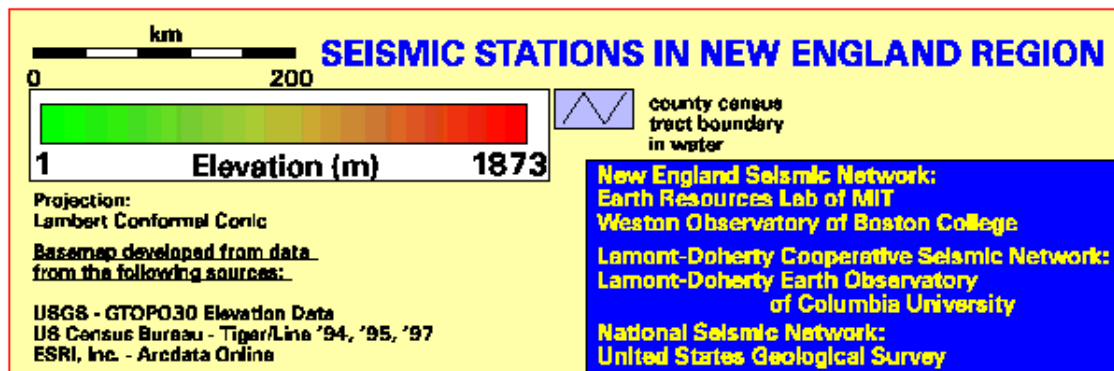
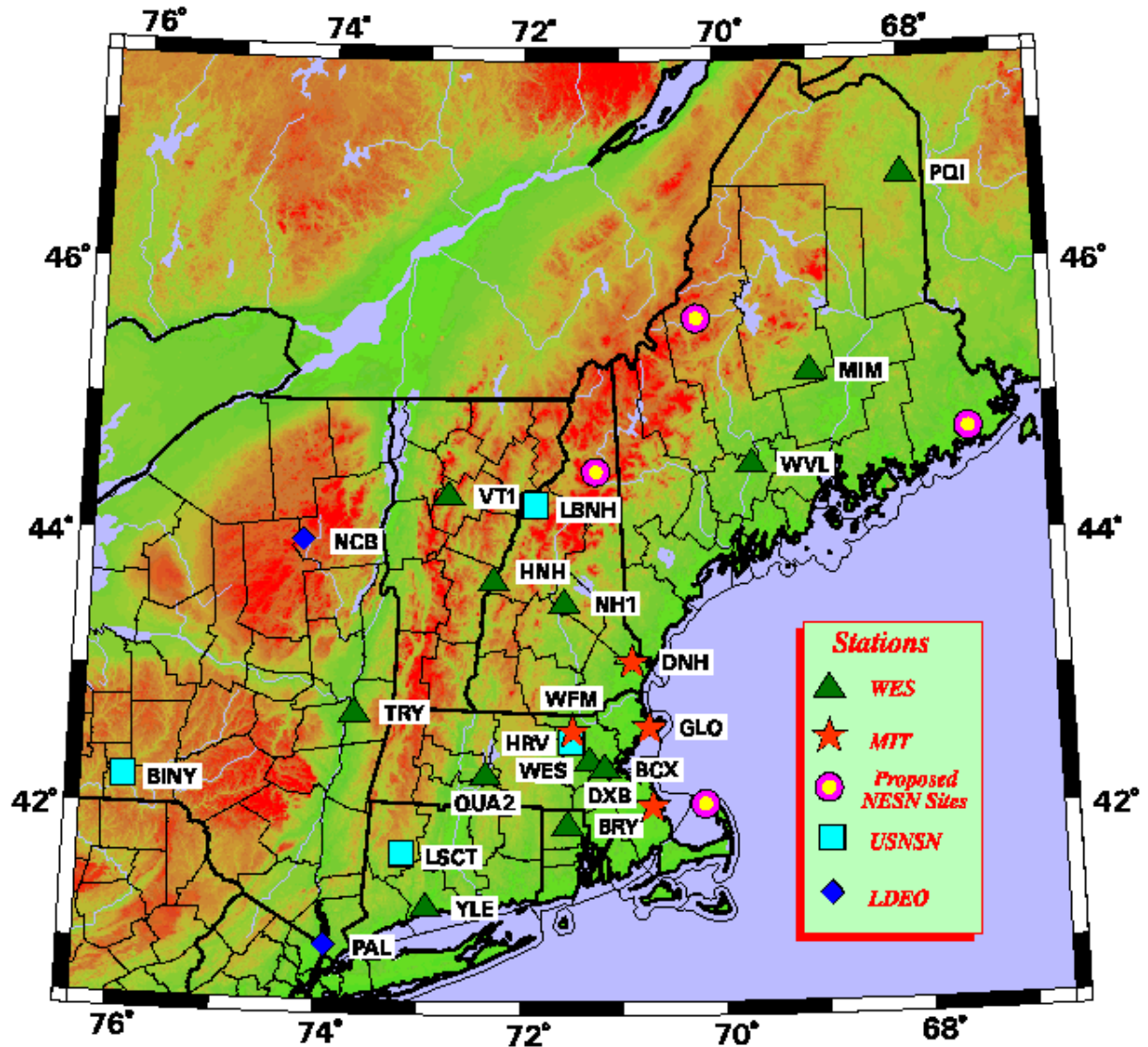
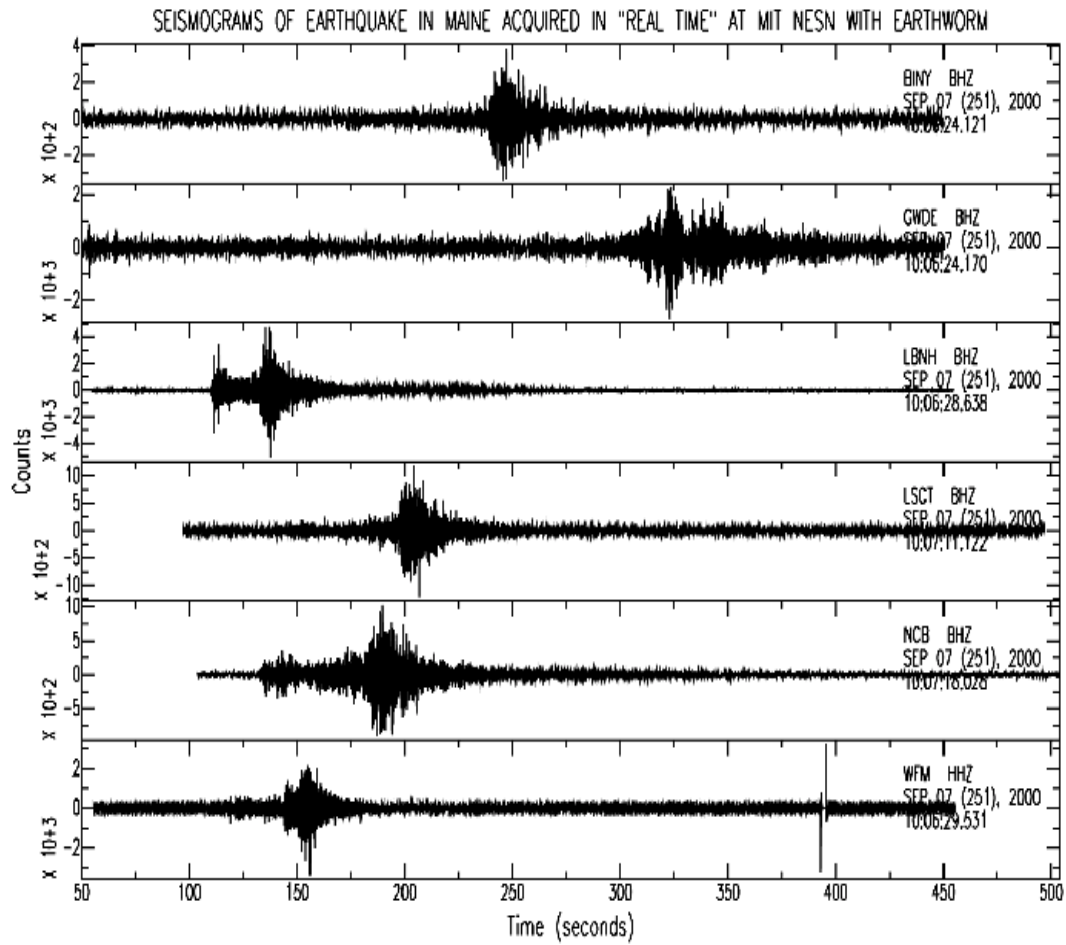


Figure 1: Stations of the New England Seismic Network (NESN). Also shown are the LDEO and some of the USNSN stations imported through Earthworm (with the exception of HRV) to the MIT NESN.



*Figure 2: Waveforms, recorded by broadband station WFM of the MIT NESN and imported in "real time" from USNSN and LDEO stations, for a local earthquake that occurred on September 7, 2000 near Waterville, ME.*

# NESN Seismicity Map

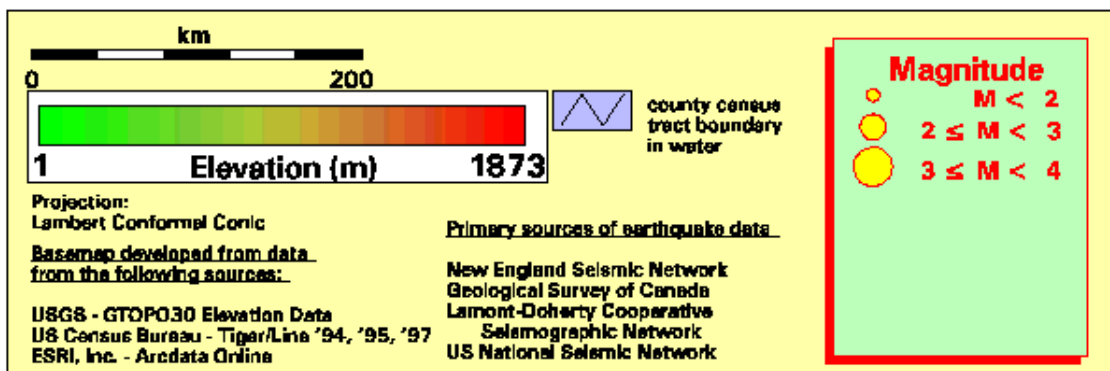
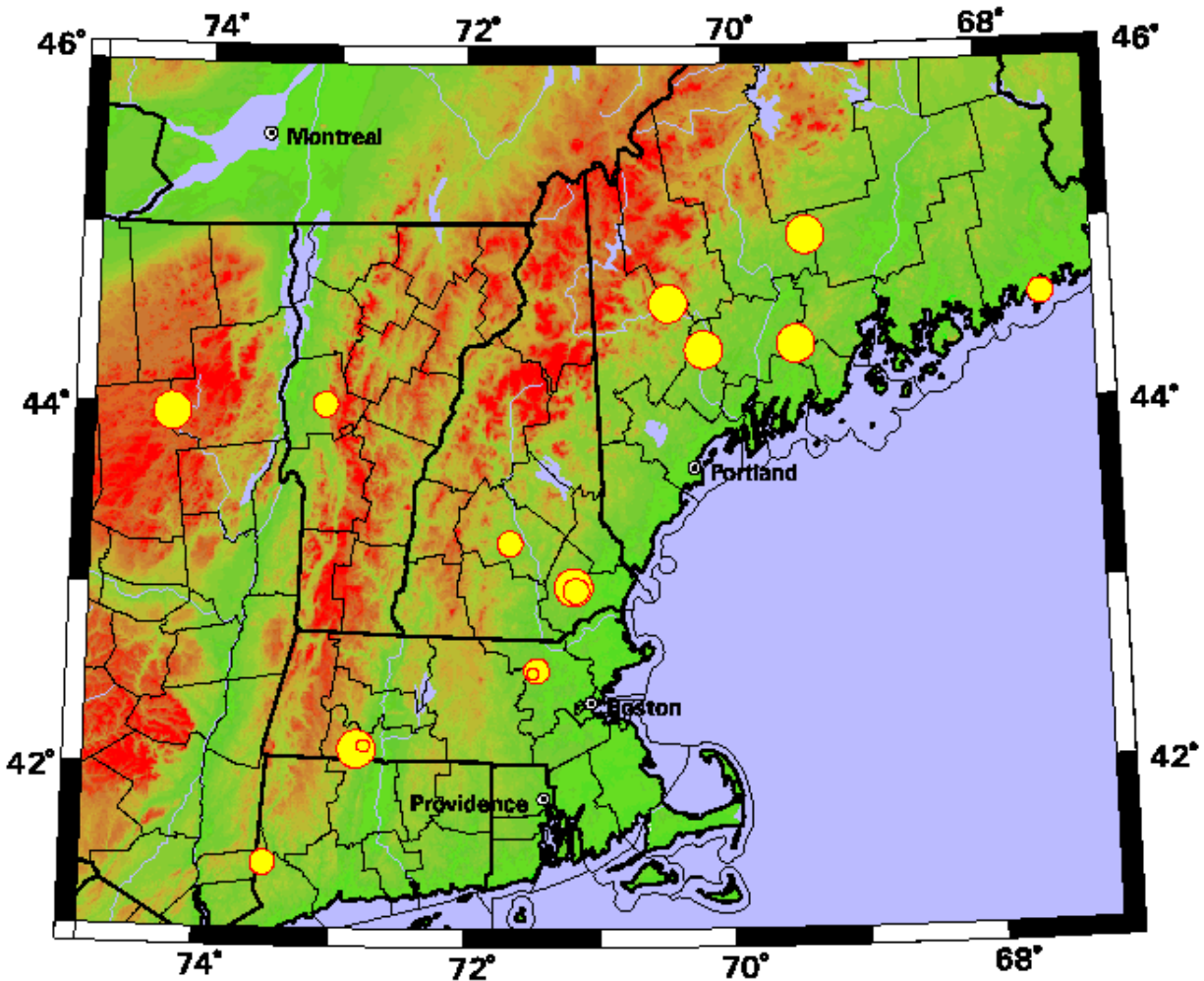


Figure 3: Seismicity located by the NESN from October 1, 1999 through September 30, 2000.